ANALOG DEVICES

AN-379
APPLICATION NOTE

ONE TECHNOLOGY WAY • P.O. BOX 9106 • NORWOOD, MASSACHUSETTS 02062-9106 • 617/329-4700

Mounting Considerations for ADXL Series Accelerometers

by Mike Shuster, Bob Briano and Charles Kitchin

As with all accelerometers, optimum performance depends on proper mounting of the device. It must be mounted so that the sensor is properly coupled to the object for which acceleration is to be measured. Also the effects of mechanical resonances must be minimized.

All mechanical structures, no matter how "solid," have mechanical resonances that result in an output signal at the resonant frequency that is larger than expected. Mechanical resonances cannot be eliminated completely. The key to successfully reducing any serious problems is to keep the resonant frequencies above the frequency band of interest or to attenuate them to acceptable levels. Structures that seem benign at rest often mechanically resonate when vibrated at high frequency.

The ADXL Series of accelerometers are intended for PC board mounting, and careful mechanical design of the PC board is important. Resonances can be difficult to determine before prototyping, but some precautions can be taken.

1. Replace or firmly attach any individual components that are flexible such as large through-hole components. Surface mount resistors and capacitors are preferred because they will not vibrate on their leads.
2. Wire-wound resistors and electrolytic capacitors can change values when they are vibrated. Again, ceramic surface mount components are best.
3. Mechanically couple a potentially problematic structure to one that has a high resonant frequency. An example of this is to firmly attach PC boards to thick bases.
4. Couple together several structures such that the combination has a dampened response: PC boards, card cages, etc.
5. Cables inside moving structures should be tied down firmly. Cables between a moving structure and a stationary one should be flexible and have a service loop.
6. Cavities, such as housings, can resonate. Filling cavities with suitable potting materials or epoxy is a good solution for this, and also prevents components from vibrating.
7. Keep all dimensions as small as possible because, in general, smaller dimensions mean that the resonances are at higher frequencies.
8. Use silicon grease or other materials on mating surfaces to improve coupling between components that are screwed together.

Many applications do not have strict requirements for being resonance free, but in some cases resonances can be critical to a successful system. The best way to test a design for resonances is to shake it, using a calibrated shaker, over the frequency band of interest using a reference accelerometer attached at critical points.

Figure 1 illustrates the ideal response of the ADXL50 which is achievable with proper fixturing or potting material. The sensor response is flat from dc to the dominant pole set by the demodulator capacitor, typically at 1.3 kHz. Figure 2 shows the response of the ADXL05.

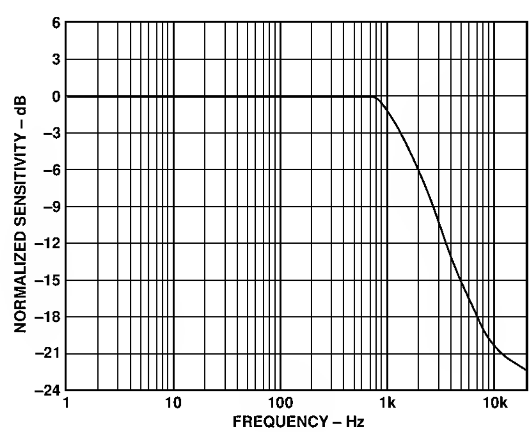

Figure 1. Ideal Response of the ADXL50

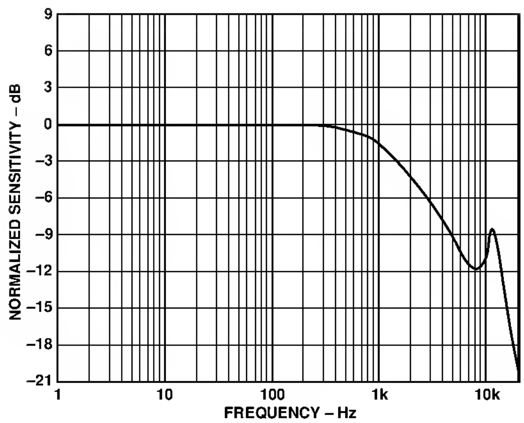

Figure 2. ADXL05 Ideal Response

(This can be varied by changing the demodulator capacitor. See application note AN-377. The sensing beam has a natural resonant frequency at 24 kHz.

Using the ADXL50 as an example, possible solutions for mechanical resonances will be illustrated. (The response of the ADXL05 will be very similar.)

All of the following measurements were made using an aluminum cube designed to hold a PC board which mounts directly to a shaker.

If the accelerometer is mounted to a PC board by soldering the leads only, then it will resonate in a complex manner in the range from 7 kHz to 9 kHz. This is caused by the accelerometer's package moving on its leads with respect to the PC board. Figure 3 illustrates a typical response from the ADXL50 when soldered to a PC board. The amplitude and frequency will vary depending on how it is held when soldered.

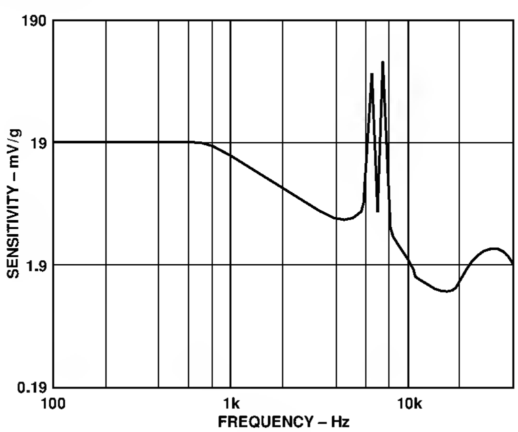

Figure 3. Response of the ADXL50 when Soldered to a PC Board

The resonance at 7 kHz will not affect the response of the ADXL50 over its typical rated bandwidth of 1.3 kHz. However, if signals at 7 kHz are potential problems, then low-pass filtering or better mounting methods may be taken.

By applying a small drop of epoxy under the seating plane of the accelerometer's package, firmly attaching it to the PC board, the resonant peak will shift to a higher frequency (approximately 12 kHz) as shown in Figure 4. This example illustrates the effectiveness that simple changes can have on this or any other resonating component.

The ultimate solution to the problem of vibrating components is to pot the entire board and all of its components with a suitable material. Figure 5 demonstrates that when encapsulated with paraffin wax (used because it is easily removable) the resonant peak is pushed out in frequency to approximately 20 kHz. Other more permanent potting materials can further reduce or eliminate the resonances.

The ADXL50 when properly mounted will not likely be the limiting component. Many other structures can resonate in a complex subsystem in the range of a few kHz if you are not careful.

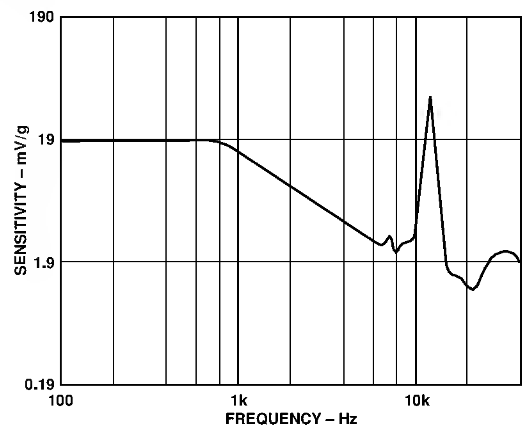

Figure 4. Response of the ADXL50 when Soldered and Epoxied to a PC Board

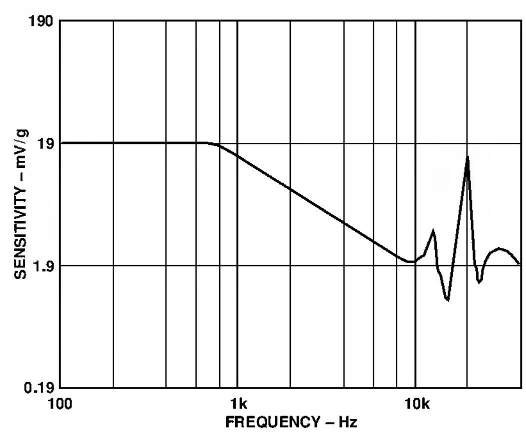

Figure 5. Response of the ADXL50 Potted with Paraffin Wax

E1895a–5–5/95

PRINTED IN U.S.A.